PB-240 297

LAKE MINNEWASKA, POPE COUNTY, MINNESOTA

Pacific Northwest Environmental
Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota Pollution Control Agency
Minnesota National Guard

December 1974

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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Report
on
Lake Minnewaska
Pope County
Minnesota
EPA Region V
Working Paper No. 114

With the cooperation of the
Minnesota Pollution Control Agency
and the
Minnesota National Guard
December, 1974

CONTENTS

	Page
Foreword	ii
List of Minnesota Study Lakes	iv, v
Lake and Drainage Area Map	vi
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	3
III. Lake Water Quality Summary	4
IV. Nutrient Loadings	8
V. Literature Reviewed	13
VI. Appendices	14

F O R E W O R D

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

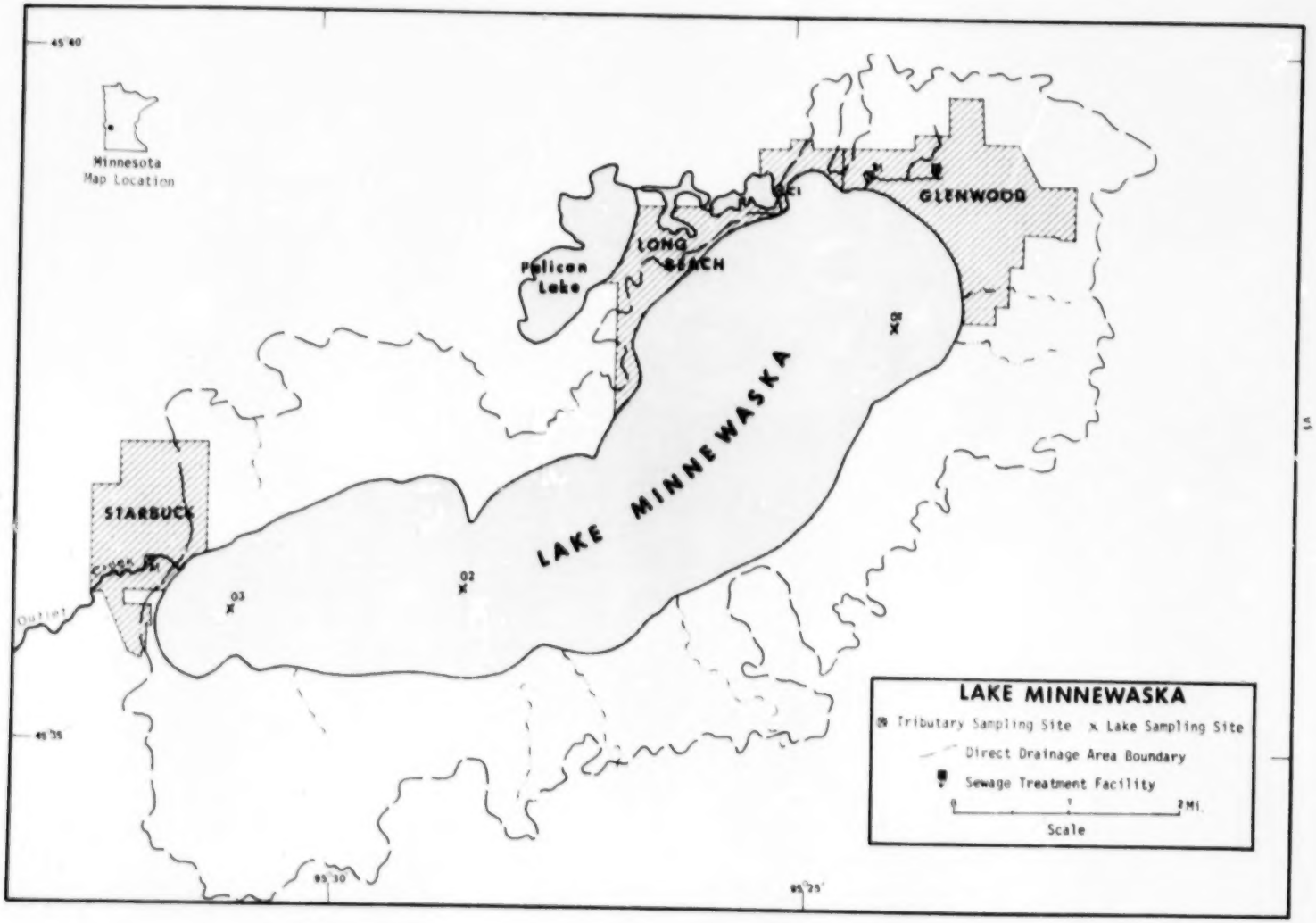
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


45°40'
Minnesota
Map Location
Pelican Lake
LONG BEACH
GLENWOOD
LAKE MINNEWASKA
STARBUCK
01
02
03
Outlet
45°35'
95°30'
95°25'
LAKE MINNEWASKA
Tributary Sampling Site
Lake Sampling Site
Direct Drainage Area Boundary
Sewage Treatment Facility
0
1
2 Mi.
Scale

LAKE MINNEWASKA

STORET NO. 2761

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Lake Minnewaska is eutrophic. Of the 60 Minnesota lakes sampled in the fall of 1972, when essentially all were well-mixed, 22 had less mean total phosphorus, 21 had less mean dissolved phosphorus, and 17 had less mean inorganic nitrogen. Of the 80 Minnesota lakes sampled, 15 had less mean chlorophyll a, and 27 had greater mean Secchi disc transparency.

Survey limnologists noted an algal bloom in progress in September.

B. Rate-Limiting Nutrient:

There was a significant loss of nutrients in the assay sample between the time of collection and the beginning of the assay, and the results are not indicative of lake conditions at the time of sampling. However, based on the level of nutrients observed at the time the sample was collected, the potential primary productivity would have been moderate.

The lake data indicate nitrogen limitation during July and October and phosphorus limitation in September.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Lake Minnewaska received a total phosphorus load at a rate slightly above the rate

proposed by Vollenweider (in press) as dangerous; i.e., a eutrophic rate (see page 12). It is estimated that the City of Glenwood contributed about 69% of the total load.

Removal of 80% of the phosphorus at Glenwood would reduce the loading rate to 0.07 $g/m^2/yr$ (an oligotrophic rate) and should improve the trophic condition of the lake.

2. Non-point sources--With a very small drainage area to lake area ratio (85/1), areal nutrient input was small compared to point-source loads; the mean annual phosphorus load from non-point sources amounted to 26.5% of the total load reaching the lake.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 7,110 acres.
2. Mean depth: 19.6 feet.
3. Maximum depth: 32 feet.
4. Volume: 139,356 acre/feet.
5. Mean hydraulic retention time: 12.7 years.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Unnamed Ditch (B-1)	2.6 mi^2	0.5 cfs
Pelican Lake outlet	46.2 mi^2	8.1 cfs
Minor tributaries & immediate drainage -	28.0 mi^2	6.5 cfs
Totals	76.8 mi^2	15.1 cfs

2. Outlet -

Outlet Creek	88.0 mi^2**	15.1 cfs

C. Precipitation***:

1. Year of sampling: 22.4 inches.
2. Mean annual: 22.7 inches.

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† DNR lake survey map (1963); mean depth by random-dot method.
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Lake Minnewaska was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet to surface) sample was composited from the three stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 18 feet at station 1, 24 feet at station 2, and 21 feet at station 3.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

		FALL VALUES (10/25/72)		
Parameter	Minimum	Mean	Median	Maximum
Temperature (Cent.)	5.9	6.2	6.2	6.3
Dissolved oxygen (mg/l)	10.0	10.6	10.8	11.2
Conductivity (μmhos)	650	666	650	750
pH (units)	8.6	8.6	8.6	8.7
Alkalinity (mg/l)	180	211	210	240
Total P (mg/l)	0.030	0.040	0.038	0.048
Dissolved P (mg/l)	0.014	0.021	0.020	0.032
NO_2 + NO_3 (mg/l)	0.050	0.061	0.060	0.070
Ammonia (mg/l)	0.060	0.069	0.070	0.080
		ALL VALUES		
Secchi disc (inches)	38	67	68	98

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/06/72	1. Dinobryon	1,031
	2. Microcystis	940
	3. Fragilaria	850
	4. Anabaena	796
	5. Melosira	380
	Other genera	687
	Total	4,684
09/01/72	1. Microcystis	5,797
	2. Merismopedia	616
	3. Aphanocapsa	543
	4. Dinobryon	290
	5. Anabaena	181
	Other genera	1,015
	Total	8,442
10/25/72	1. Fragilaria	3,268
	2. Asterionella	1,205
	3. Dinobryon	602
	4. Microcystis	331
	5. Gomphosphaeria	226
	Other genera	512
	Total	6,144

2. Chlorophyll *a* -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
07/06/72	01	10.9
	02	9.5
	03	9.3
09/09/72	01	9.3
	02	8.8
	03	8.4
10/25/72	01	4.6
	02	3.4
	03	4.4

C. Limiting Nutrient Study:

There was a significant loss of nutrients in the assay sample between the time of collection and the beginning of the assay, and the results are not indicative of lake conditions at the time of sampling. However, based on the level of nutrients measured at the time the sample was collected, the potential primary productivity would have been moderate.

The lake data indicate nitrogen limitation during July (N/P ratio = 4/1) and October (N/P = 6/1) and phosphorus limitation in September (N/P = 14/1).

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of April and May when two samples were collected. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using nutrient loads, in lbs/mi^2/year, at station C-1 and multiplying by the ZZ area in mi^2.

The City of Glenwood did not participate in the Survey, and nutrient loadings were estimated at 2.5 lbs P and 7.5 lbs N/capita/year. The estimated Glenwood nutrient loads exceeded the loads measured in the unnamed ditch at station B-1, and the non-point loads of the ditch were estimated in the same way as the ZZ loads.

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* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receivin Water
Glenwood	2,584	act. sludge	0.258**	ditch to Lake Minnewaska

2. Known industrial - None

* Anonymous, 1974.
** Breimhurst, 1965.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed Ditch (B-1)	50	0.5
Pelican Lake outlet	830	8.9
b. Minor tributaries & immediate drainage (non-point load) -	500	5.3
c. Known municipal -		
Glenwood	6,460	69.2
d. Septic tanks* -	390	4.2
e. Known industrial - None	-	-
f. Direct precipitation** -	1,110	11.9
Total	9,340	100.0

2. Outputs -

Lake outlet - 940

3. Net annual P accumulation - 8,400 pounds

* Estimate based on 351 seasonal, 91 permanent homes, and 12 resorts on the lakeshore; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed Ditch (B-1)	1,490	1.0
Pelican Lake outlet	26,410	18.1
b. Minor tributaries & immediate drainage (non-point load) -	16,020	10.9
c. Known municipal -		
Glenwood	19,380	13.2
d. Septic tanks* -	14,490	9.9
e. Known industrial - None	-	-
f. Direct precipitation** -	68,500	46.8
Total	146,290	100.0

2. Outputs -

Lake outlet 31,270

3. Net annual N accumulation - 115,020 pounds

* Estimate based on 351 seasonal, 91 permanent homes, and 12 resorts on the lakeshore; see Working Paper No. 1.
** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
Pelican Lake outlet	18	572

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	1.3	1.2	20.6	16.2
grams/m^2/yr	0.15	0.13	2.3	1.8

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Minnewaska:

"Dangerous" (eutrophic rate)	0.14
"Permissible" (oligotrophic rate)	0.07

V. LITERATURE REVIEWED

Anonymous, 1974. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Breimhurst, Lawrence H., 1965. Report on operation of oxidation ditch sewage treatment plant, Glenwood, Minnesota. MN Dept. of Health, Minneapolis.

Peterson, George, and Kyle Bishop, 1971. Report on investigation of water quality of Lake Minneswaska, Pope County. MPCA, Minneapolis.

Schilling, Joel, 1974. Personal communication (lake map). MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz A. Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2761 MINNEWASKA LAKE

TOTAL DRAINAGE AREA OF LAKE 88.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2761A1	88.00	1.63	1.00	12.90	41.00	29.80	27.70	19.00	12.40	16.50	8.40	5.90	4.30	15.07
2761B1	2.64	0.08	0.03	0.71	0.97	0.81	0.81	0.58	0.32	0.66	0.21	0.14	0.19	0.46
2761C1	46.20	0.93	7.66	7.75	19.60	14.40	13.80	9.62	6.18	9.47	3.85	2.60	2.35	8.15
2761Z7	39.10	1.03	0.62	6.75	15.90	12.00	11.70	8.11	5.17	8.36	3.29	2.16	2.29	6.46

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 88.00
SUM OF SUB-DRAINAGE AREAS = 87.94

TOTAL FLOW IN = 181.01
TOTAL FLOW OUT = 180.50

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2761A1	10	72	21.30	15	22.00				
	11	72	15.90	10	20.00				
	12	72	17.10	6	21.00				
	1	73	7.47	7	8.10	27	7.00		
	2	73	6.77	6	6.70				
	3	73	56.50	10	75.00				
	4	73	37.40	25	39.00	30	27.00		
	5	73	30.80	20	31.00	30	28.00		
	6	73	12.70	11	14.60				
	7	73	6.63	17	7.73				
	8	73	7.09	7	9.80				
	9	73	6.93	10	9.60				
2761B1	10	72	0.67	15	0.98				
	11	72	0.53	10	0.96				
	12	72	0.60	6	1.00				
	1	73	0.39						
	2	73	0.15	6	0.20				
	3	73	1.23	10	2.10				
	4	73	0.90	15	0.90	30	0.70		
	5	73	0.74	20	0.80	30	0.60		
	6	73	0.40	11	0.60				
	7	73	0.15	17	0.17				
	8	73	0.22	7	0.35				
	9	73	0.22	10	0.62				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA

LAKE CODE 2741 [illegible] LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2741C1	10	73	[illegible]	15	11.00				
	11	73	7.53	13	9.70				
	12	73	[illegible]	4	13.00				
	1	74	4.54						
	2	74	[illegible]	4	40.00				
	3	74	34.00	16	23.00				
	4	74	13.[illegible]	15	14.00	30	14.00		
	5	74	15.[illegible]	30	11.00	30	14.00		
	6	74	6.76	11	7.50				
	7	74	2.51	17	2.00				
	8	74	4.21	1	3.10				
	9	74	6.26	13	6.00				
2741Z7	10	73	5.42	15	4.25				
	11	73	5.23	16	4.10				
	12	73	9.23	4	12.00				
	1	74	5.14						
	2	74	2.76	4	2.70				
	3	74	30.43	16	20.00				
	4	74	15.41	15	15.00	30	11.00		
	5	74	13.20	23	9.00	30	12.00		
	6	74	5.73	11	6.40				
	7	74	2.11	17	1.70				
	8	74	3.53	1	2.60				
	9	74	5.03	15	5.30				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/12/30

27A101
45 3R 07.0 095 23 56.0
MINNEWASKA LAKE
27 MINNESOTA

11EPALES 2111202
3 001M FEET DEPTH

DATE FROM TO	TIME	DEPTH OF DAY	FEET	00010 WATER TEMP C-NT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/06	16 45	0000		22.0	16.3	9R	580	8.40	230	0.030	0.040	0.021	0.010
	16 45	0014		21.0	7.8		600	8.30	216	0.040	0.040	0.035	0.013
72/09/01	13 45	0000		27.4		42	640	8.70	226	0.130	0.150	0.042	0.020
	13 45	0004		21.3	10.7		625	8.70	236	0.140	0.150	0.035	0.022
	13 45	0010		21.1	4.3		650	8.65	192	0.130	0.140	0.042	0.019
	13 45	0015		20.9	7.1		630	8.65	216	0.170	0.180	0.034	0.025
72/10/25	13 05	0000				3R	750	8.70	230	0.070	0.080	0.037	0.016
	13 05	0004		5.4	11.2		650	8.70	223	0.060	0.080	0.047	0.032
	13 05	0015		5.3	11.2		665	8.70	210	0.050	0.060	0.040	0.018

DATE FROM TO	TIME	DEPTH OF DAY	FEET	32217 CHLOROPHYL UG/L
72/07/06	16 45	0000		10.0J
72/09/01	13 45	0000		9.4J
72/10/25	13 05	0000		4.5J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

276102
45 36 12.0 095 28 30.0
MINNEWASKA LAKE
27 MINNESOTA

11EPALES
3

2111202
0025 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/06	17	15 0000	22.0	11.0	82	590	8.40	242	0.030	0.030	0.028	0.014
	17	15 0010	21.5	14.0		580	8.40	230	0.030	0.030	0.027	0.014
	17	15 0023	20.0	4.4		595	8.20	250	0.050	0.150	0.039	0.130
72/09/01	14	20 0000	20.5		72	640	8.55	228	0.080	0.120	0.031	0.030
	14	20 0004	20.5	6.2		640	8.55	212	0.080	0.130	0.029	0.019
	14	20 0015	20.3	7.2		645	8.50	220	0.100	0.130	0.044	0.016
	14	20 0024	19.8	6.7		645	8.45	230	0.120	0.150	0.030	0.013
72/10/25	13	40 0000			60	675	8.60	180	0.070	0.070	0.030	0.014
	13	40 0004	6.2	10.0		650	8.60	240	0.050	0.060	0.037	0.019
	13	40 0015	6.2	10.3		660	8.60	220	0.060	0.070	0.048	0.028
	13	40 0024	6.2	10.0		650	8.60	200	0.060	0.070	0.047	0.025

DATE FROM TO	TIME OF DAY	DEPTH FEET	32211 CHLRPHYL A UG/L
72/07/06	17	15 0000	9.5J
72/09/01	14	20 0000	8.2J
72/10/25	13	40 0000	3.4J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

27 103
45 36 05.0 095 31 00.0
MINNEWASKA LAKE
27 MINNESOTA

11 PALES
3

2111202
0023 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CONDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/06	17 45	0000	22.0	15.5	96	600	8.40	220	0.050	0.040	0.025	0.011
	17 45	0010	22.0	15.5		590	8.40	240	0.030	0.040	0.031	0.012
	17 45	0021	20.5	4.4		600	8.30	224	0.060	0.060	0.040	0.014
72/09/01	14 40	0000	20.3		66	630	8.52	214	0.100	0.130	0.027	0.014
	14 40	0004	20.3	5.6		640	8.52	194	0.090	0.120	0.033	0.013
	14 40	0015	20.2	7.4		640	8.50	236	0.090	0.130	0.033	0.015
	14 40	0030	20.1	7.6		700	8.53	242	0.090	0.150	0.030	0.016
72/10/25	14 00	0000			48	650	8.60	220	0.050	0.070	0.032	0.017
	14 00	0004	7.3	11.4		650	8.66	200	0.050	0.060	0.038	0.022
	14 00	0015	7.2	11.4		650	8.60	210	0.070	0.070	0.037	0.020
	14 00	0030	7.1	11.1		640	8.61	190	0.060	0.070	0.043	0.023

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT
72/07/06	17 45	0030	22.0
72/09/01	14 40	0030	20.1
72/10/25	14 00	0000	7.3

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/30

2761A1 LS2761A1
45 36 30.0 095 32 00.0
OUTLET CREEK
27019 7.5 STARBUCK
O/LAKE MINNEWASKA
ST HWY 29 BRDG S OF STARBUCK
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 30		0.104	0.850	0.126	0.009	0.037
72/11/10	10 58		0.042	0.950	0.005K	0.005K	0.032
72/12/03	12 30		0.012	0.670	0.011	0.005K	0.016
73/01/27	12 23		0.115	0.960	0.169	0.025	
73/02/04	11 20		0.021	0.840	0.029	0.005K	0.015
73/03/10	10 45		0.056	1.500	0.154	0.023	0.023
73/04/15	10 55		0.013	0.990	0.056	0.005K	0.030
73/04/30	12 10		0.010K	1.700	0.026	0.008	0.040
73/05/20	12 10		0.011	1.200	0.054	0.005K	0.030
73/06/11	13 00		0.010K	0.840	0.060	0.011	0.040
73/07/17	11 30		0.011	1.050	0.019	0.008	0.035
73/08/07	13 30		0.010K	0.960	0.120	0.018	0.040
73/09/10	14 45		0.010K	1.000	0.038	0.012	0.050

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

27S1R1 LS27S1R1
45 39 30.0 095 24 00.0
UNNAMED DITCH TO LK MINNEWASKA
27 7.5 GLENWOOD
T/LAKE MINNEWASKA
HWYS 28/29 W GLENWOOD BELOWSTP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 D-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 00		3.000	3.200	0.154	1.100	1.130
72/11/10	10 38		1.730	5.000	0.054	0.255	
73/02/04	11 00		4.730	0.460	0.470	0.960	1.100
73/03/10	10 30		3.100	0.430	0.135	0.805	0.850
73/04/15	10 35		2.200	3.630	0.710	1.300	1.200
73/04/30	11 40		2.300	2.500	1.890		1.570
73/05/20	11 40		2.300	3.230	1.680	1.435	1.600
73/05/30	11 40		2.300	3.500	1.750	1.300	1.570
73/06/11	12 30		2.300	3.530	1.600	1.600	2.000
73/07/17	11 30		2.300	2.700	1.500	1.740	1.950
73/08/07	12 40		2.100	3.100	1.370	2.000	2.100
73/09/10	14 25		2.400	4.100	1.000	2.100	3.150

STORET RETRIEVAL DATE 74/10/30

27610I LS2761C1
45 39 00.0 095 25 00.0
PELICAN LAKE /LAKE MINNEWASKA CN
27 7.5 GLEN#OOD
T/LAKE MINNEWASKA
2ND ROAD XING SW OF LONG BEACH
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	09 10		0.156	1.300	0.198	0.019	0.048
72/11/10	10 45		0.177	1.540	0.008	0.017	0.040
72/12/08	12 06		0.138	1.540	0.231	0.008	0.042
73/02/04	11 05		0.120	1.700	0.490	0.005K	0.035
73/03/10	10 40		0.470	3.990	1.790	0.110	0.155
73/04/15	10 40		0.010K	1.470	0.096	0.011	0.065
73/04/30	11 50		0.012	1.320	0.060		0.050
73/05/20	11 50		0.013	1.470	0.058	0.005K	0.065
73/05/30	11 50		0.016	1.300	0.060	0.011	0.055
73/06/11	12 45		0.023	1.340	0.075	0.015	0.040
73/07/17	11 05		0.039	1.540	0.056	0.015	0.065
73/08/07	12 50		0.015	1.410	0.189	0.018	0.060
73/09/10	14 35		0.018	2.700	0.058	0.013	0.050

K VALUE KNOWN TO BE LESS
THAN INDICATED